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Facsimile Cover Sheet

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Date/Time: 22 Mar 2002 ______ am / pm EST

Pages including Cover: ____

Regarding: Activities

Comments:

Will call to discuss.

Randy

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5959 Las Colinas Boulevard
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Brian P. Flannery
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ExxonMobil

March 18, 2002

VIA FACSIMILE - #202.456.6021

Dr. John H. Marburger
Assistant to the President for Science and Technology
Eisenhower Executive Office Bldg, Room 424
17th Street and Pennsylvania Ave, NW
Washington, DC 20502-0001

Dear Dr. Marbuger:

We understand that the administration is considering ways to improve the U.S. approach to scientific research on climate change. In that respect I would like to share recommendations that ExxonMobil developed and communicated to a number of people and institutions in discussions to improve USGCRP last year.

As background to our recommendations, note that ExxonMobil has been involved in scientific research on climate change for over 20 years. This involves support for and development of research at leading institutions (such as MIT, Carnegie Mellon, Stanford and the Bermuda Biological Station for Research). We also conduct our own research, often in collaboration with leading academic scientists. For example, Dr. Haroon Kheshgi and I participated as lead authors in the Intergovernmental Panel on Climate Change, and have published over 45 papers (30+ in peer-reviewed journals) on a range of climate topics. These include detection and attribution of human induced change, transient climate models, the carbon cycle, the role of methane and aerosols. From this engaged perspective we have developed the attached recommendations.

Fundamentally, the proposals contain three elements:

- Focussed research to address known key areas of scientific uncertainty with quantitative deliverables and an assessment of their policy relevance,
- A U.S. assessment process that would augment and contribute to the IPCC, and
- Increased US capacity in climate modelling and monitoring.

We hope that these recommendations will be of value to you as the administration addresses this important task. As we have offered, I hope that we might have an opportunity to discuss these recommendations directly with you in Washington.

Sincerely,

Brian P. Flannery

c: A. G. Randol

Attachment

Recommendations to Improve U.S. Global Climate Change Research and Assessment Capabilities (June 15, 2001)

A programmatic approach to assess and reduce uncertainty in climate prediction

Gaps and uncertainty in observations and scientific understanding of critical climate processes limit current ability to predict the rate and consequences of future climate change. For climate change policy consideration the most critical scientific issues concern:

- The extent of natural variability as a contributor to current and past climate changes.
- Detection of climate change from human influences: with what confidence can science confirm that climate changes have occurred that can be attributed to human influence, and that allow us to gain confidence in predictions of human influences on future change.
- Ability to predict future consequences of climate change: with what confidence can science predict: 1) future emissions and concentrations of greenhouse gases and aerosols, 2) associated changes in climate, and 3) the impacts of climate change on humans and natural ecosystems.

The natural science of climate change is limited today by:

- Lack of knowledge of key climate processes that must be incorporated in climate models both to predict future climate change and its impacts, and to explain past natural variability.
- Limited availability of data required to calibrate and validate climate processes and models and to provide a basis for tests of the ability of models to match natural climate variability and to distinguish what influence humans may be having on climate today.
- Limited computer capacity to represent climate processes at the necessary level of complexity and spatial and temporal resolution.

Forecasts of climate change and its impacts depend also on improvements in other areas of social and natural science that are required to predict future emissions of greenhouse gasses (especially technological forecasts of future energy supply and end use), and the implications of climate change on society and ecosystems. Many of these research areas involve integrated application of knowledge from natural scientists, economists, technologists, and other social scientists.

To promote better public policy it is important to understand the complexity and linkages among these scientific issues, and to develop

- Focussed research programs with tangible deliverables that address specific significant, known scientific uncertainties,
- Improved scientific assessments,
- Enhanced technical and management capacity for an improved national infrastructure to observe, analyze, understand, and predict future climate change and its impacts.

Such an integrated program would more accurately portray current scientific understanding including uncertainty, how available information aids and limits policy choices today, and put in place quantifiable programs and capacity building to improve understanding.

Focussed Research Programs on Known Areas of Significant Uncertainty
The central idea is to focus a defined part of taxpayer funded research on programs to improve the basis for prediction of climate change through creation of dedicated, stewarded programs that improve understanding of known, key areas of uncertainty.

Each specific program should include elements that:
- Identify and quantify those areas of science that pose major limitations to climate predictions today
- Explain why these areas are important for public policy
- Propose dedicated, stewarded research initiatives in critical areas aimed to progress scientific understanding, including quantifiable measures of progress
- Propose a process for periodic scientific feedback and assessment to measure progress in scientific understanding, and evolve research support

Management of both the specific targeted programs and the entire package should involve periodic review by scientific experts to assess progress and redefine programs and priorities. For instance this could mean sunsetting of programs where issues have been satisfactorily resolved or where no progress has occurred, as well as establishment of new initiatives.

An essential element of the proposal is the need to define *quantifiable measures of progress*. For example, for natural temperature variability this might involve a quantification of the amounts of variability over a range of scales in time and space. For factors that affect radiative forcing it might be measured in watts per square meter.

Much work has already been done to identify key areas of uncertainty and research opportunities (*Global Environmental Change: Research Pathways for*

the next Decade, NRC 1999). However, those discussions have not sought to place the uncertainty in the context of why it is important to public policy and how it might limit current ability to detect climate change, to attribute climate change to human activity, or how it might limit the ability to predict future climate change and its impacts.

I attach a list of natural science areas that are both important sources of uncertainty in climate change forecasts and where research advances could be made. Advances in some areas (e.g. regional climate change forecasts) depend on advances in other areas (e.g. ocean/climate interactions). This is especially true for model/data intercomparisons, which will depend on characterization of climate change forecasts.

Each of these, and perhaps others, should become the focal point for a specific, agency-managed program with deliverables and scientific review and feedback to guide the project at periodic intervals.

If the U.S. establishes a climate research agenda focussed in part on understanding and resolving well-known, significant scientific uncertainties that currently limit understanding, the results of such programs would provide powerful, objective information for future IPCC assessments. Anyone who has been involved with the Intergovernmental Panel on Climate Change (IPCC), recognizes its limitations and politicization. This occurs at many levels and involves the fundamental framing of issues, tensions between various national and regional views, tensions between different disciplines, and on and on. Many scientists are no longer willing even to become involved with IPCC. While no assessment in an area this complex can be without political differences, a key matter of some urgency for the United States is why should we as a nation rely solely on the IPCC as a source of information to frame U.S. policy.

<u>Improved National and International Assessments of Climate Change</u>
The U.S. should establish its own assessment process: one that more clearly defines terms of reference relevant to U.S. issues and needs. Such a U.S. process might share and contribute to the IPCC, but other aspects, for example concerning assessments of impacts and options to address climate change could be far better focussed in a U.S. process.

In addition the U.S. should seek to improve the IPCC process. The most significant issues concern preparation and approval of the Summaries for Policymakers that result from government negotiations. However, there are also opportunities to improve development of the terms of reference and procedures for selection of authors of chapters in the underlying reports and the development of their summaries. A major frustration to many is the all-too-apparent bias of IPCC to downplay the significance of scientific uncertainty and gaps, and the role that future research might or might not play in resolving them. These could be prescribed as important areas to assess.

If the U.S. established its own assessment process it would contribute important information that could help shape improvements in future IPCC assessments.

Improved National Research Capacity

This has been the subject of numerous studies by the National Research Council that point out serious limitations in our nation's observational and computational capacity (see *The Science of Regional and Global Climate Change Putting Knowledge to Work*, NRC 2000). In turn these deficiencies limit our ability to resolve significant uncertainties. It is not just hardware that causes these limits. Our outstanding academic research community rightly thrives and plays its most important role in curiosity driven, fundamental and applied research. Many of the most critical gaps that have been identified require institutions and personnel with the capability to undertake long-term, routine and operational programs. These are not the forte of universities. They require dedicated staff and resources.

In closing these three proposals are not intended to be the basis for the entire portfolio of research to address this topic of enormous national importance. Resources must also be available to fund curiosity and technology driven fundamental research that may generate unanticipated breakthroughs and new leads that could be decisive to our understanding of climate change.

However, in an area of such importance, where well known scientific gaps and uncertainty limit knowledge and prevent prediction, the three elements of this proposal could improve long-term national capacity to address climate change:

Focussed research programs on known areas of uncertainty: develop specific, targeted programs with measurable deliverables and scientific oversight.

National and International Assessments: Create a U.S. assessment process that serves the needs of our nation and that can allow us to make an enhanced contribution to an improved international process.

Infrastructure: enhance national computational and observational capabilities in this area, and establish an improved management framework for more routine and operational activities.

Areas for Potential Improvements in the Science of Climate Change

The following is a list of science areas that are primary sources of uncertainty in climate change forecasts. Each area is followed by a list of researchers who would be useful in future research planning.

Climate Model/Data Intercomparisons (Detection of Climate Change): What have we learned, and what do we expect to learn about global climate change from climate change data? This is a general question is often improperly encapsulated in the question: have we detected greenhouse warming from human activities? Of course the more important question is: have we detected human induced climate change that leads us to believe that future climate change will have serious negative impacts? These questions require climate data, predictions of how climate should behave (both the climate change signal and variability including characterization of uncertainty), and methods to compare predictions to data, including their uncertainty. To date, in the idealized studies of climate change detection, uncertainties in climate data and predictions have not been fully included. There is a near-term potential to advance this area by better representation of data and predictions, and by inclusion of types of data.

Natural climate variability: The ability to detect a human influence on climate depends critically on the ability to isolate any *signal* of human induced change from the *noise* of natural variability. This requires improved quantitative understanding of the temporal and spatial distribution of natural variability, especially over time scales from decades to centuries, and the factors and processes that contribute to natural variability. As well, it requires scientifically justified statistical methods to describe natural variability and to distinguish human influences objectively.

Regional Climate Change: While there has been continued debate on the characterization of uncertainty of equilibrium climate sensitivity, there has been limited discussion of uncertainty in the regional patterns of climate change. Current information is primarily from GCM intercomparisons. Better understanding of the potential causes of different patterns of warming is needed in order to represent our expectation of climate change for use in detection studies, and for assessment of potential impacts of climate change. In the near-term, uncertainty in regional patterns could be characterized.

Chaos and Limits to Predictability: Many aspects of climate and weather are known to behave in chaotic fashion. The future state of the system depends so strongly on specific initial conditions that detailed deterministic predictions are not possible. Rather, outcomes can only be described in terms of distributions of probable states. This has important implications for prediction of regional climate change and its impacts, as well as for quantitative detection of climate change in

the presence of natural variability in climate and in the predictions of climate models.

Cloud Feedbacks: Observations demonstrate that models of current climate do not adequately describe the role of clouds in today's climate. Improving the ability of climate models to describe clouds today is a major challenge. An even greater challenge is to predict how clouds may differ if climate changes. Cloud feedback is considered to be the largest contributor to uncertainty of climate sensitivity. This uncertainty has been represented using different parameterizations in climate models where plausible ranges of cloud treatment lead to factors of three differences in estimates of climate sensitivity. There are ongoing campaigns to measure clouds by satellite and aircraft. Implications of these measurements remain unclear. Key issues to be resolved: what is the current distribution of clouds? How well do climate models represent today's cloudiness? What factors might alter the effects of clouds in changed climate? How does this knowledge limit predictive capabilities? This program must be closely linked to the next one on aerosols.

Aerosol Effects: Aerosol effects play an important role in comparison of climate data and models. Through their direct effect aerosols both scatter and absorb sunlight, and through their indirect effect they may alter radiative properties of clouds. Aerosols are thought to be the largest uncertainty in climate forcing. To date, uncertainties in the regional and historical patterns of aerosol forcing have not been considered in climate change detection studies. Indirect aerosol effects should have a different regional pattern than direct effects, since cloud prevalence has a different pattern. There is potential for narrowing uncertainty of direct effects of aerosols by direct measurement campaigns. In the near term, the potential for narrowing uncertainties in indirect effects is limited. Key issues concern the actual distribution, composition and radiative effects of aerosols in today's atmosphere; regional and time dependent distribution of aerosol sources in the past; improved models to represent the radiative and chemical effects of aerosols on the atmosphere; and improved assessment of the importance of aerosol effects on studies of detection of a human influence on climate.

Global Carbon Cycle: There is uncertainty in projections of future sinks of CO2 by the oceans and biosphere. Clues to the mechanisms that drive these sinks come from estimates of the current locations of sinks. Measurements of the atmospheric field of CO2, isotopes and oxygen remain a good prospect for estimating the location of sinks. Improved modeling, mathematical inversion approaches designed for this problem, and further measurements are needed.

Ocean/Climate Interactions: Shifts in ocean circulation are one mechanism that influences the regional pattern of climate change, and uptake of heat by oceans plays a dominant role in establishing the rate of climate change with time. Ocean circulation may well be a complex system in which changes might not be predicted from past behavior. Global ocean circulation models currently differ

Economic Impact of Climate Change Policy On Major Industrial Economies

by

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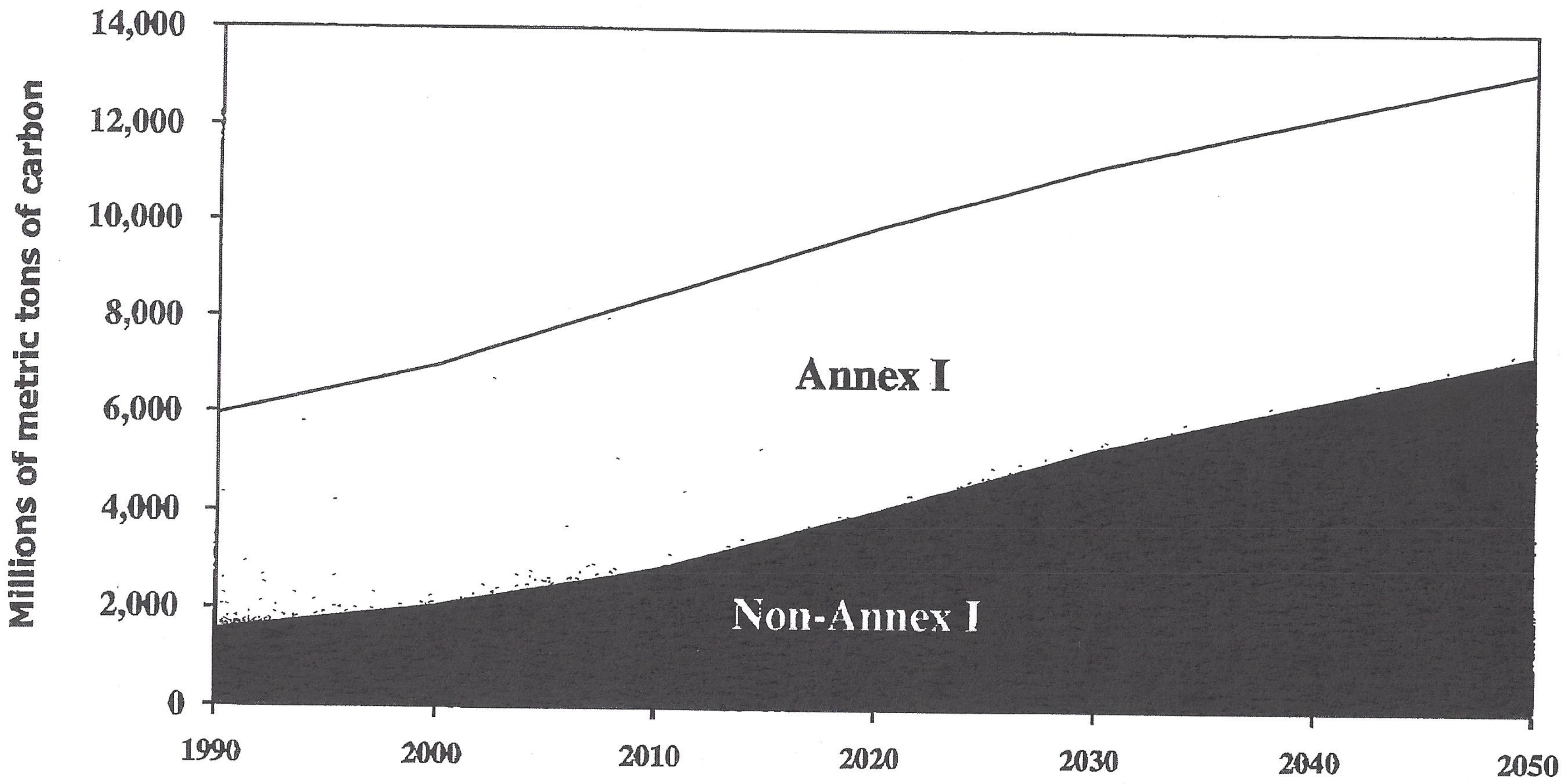
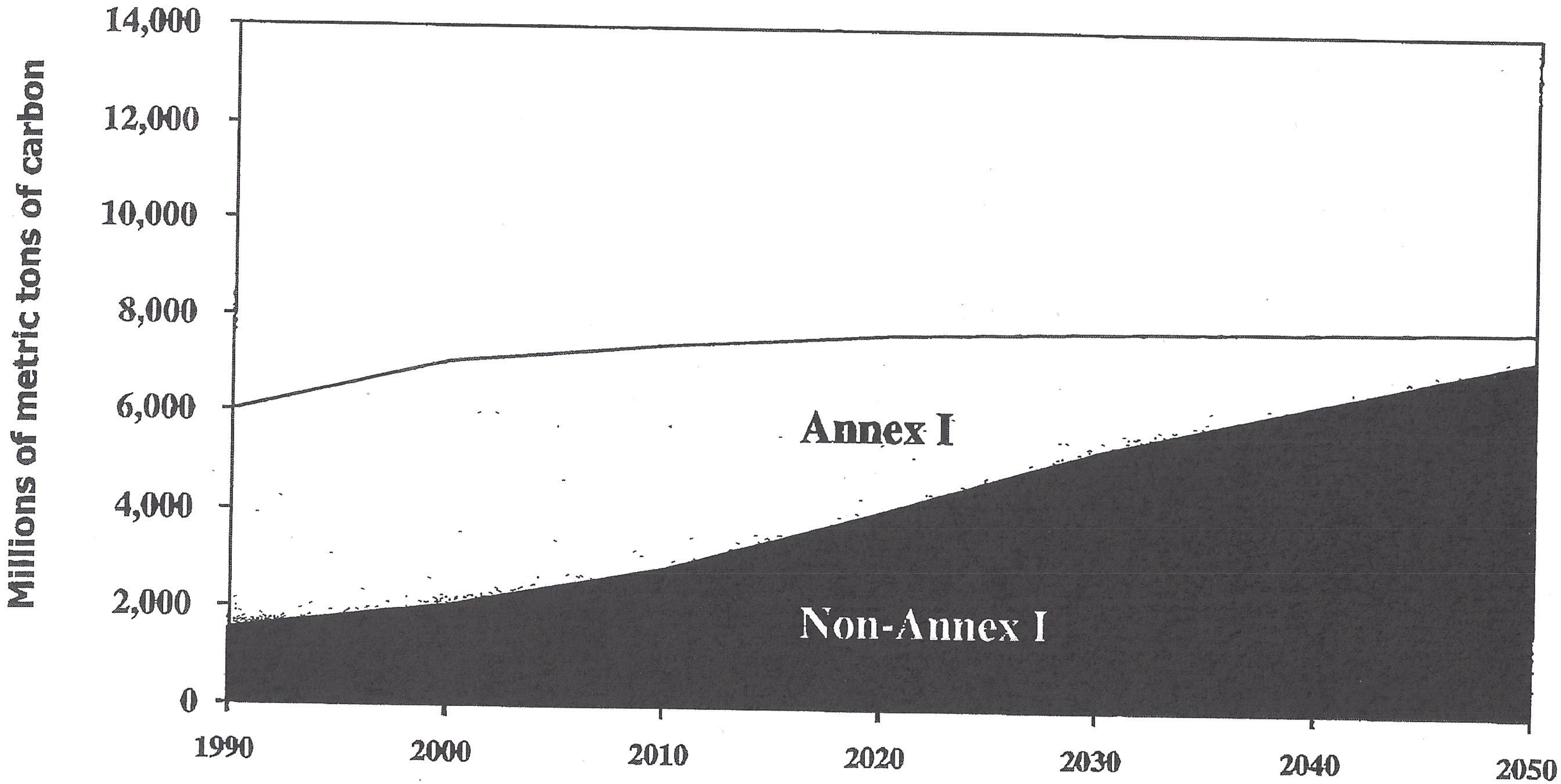
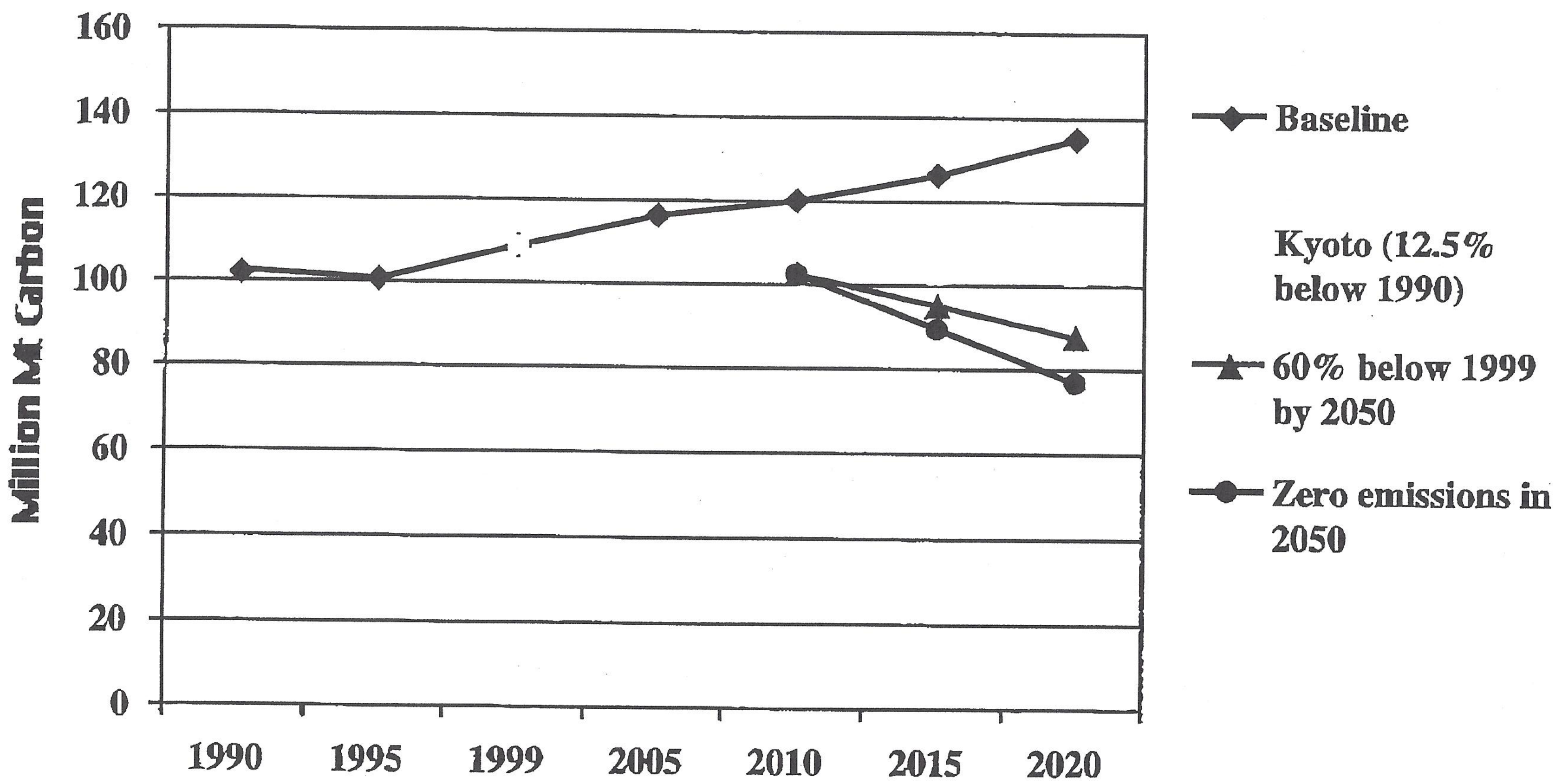
Carbon Emissions for Developed (Annex I) and Developing Countries: Reference Forecast



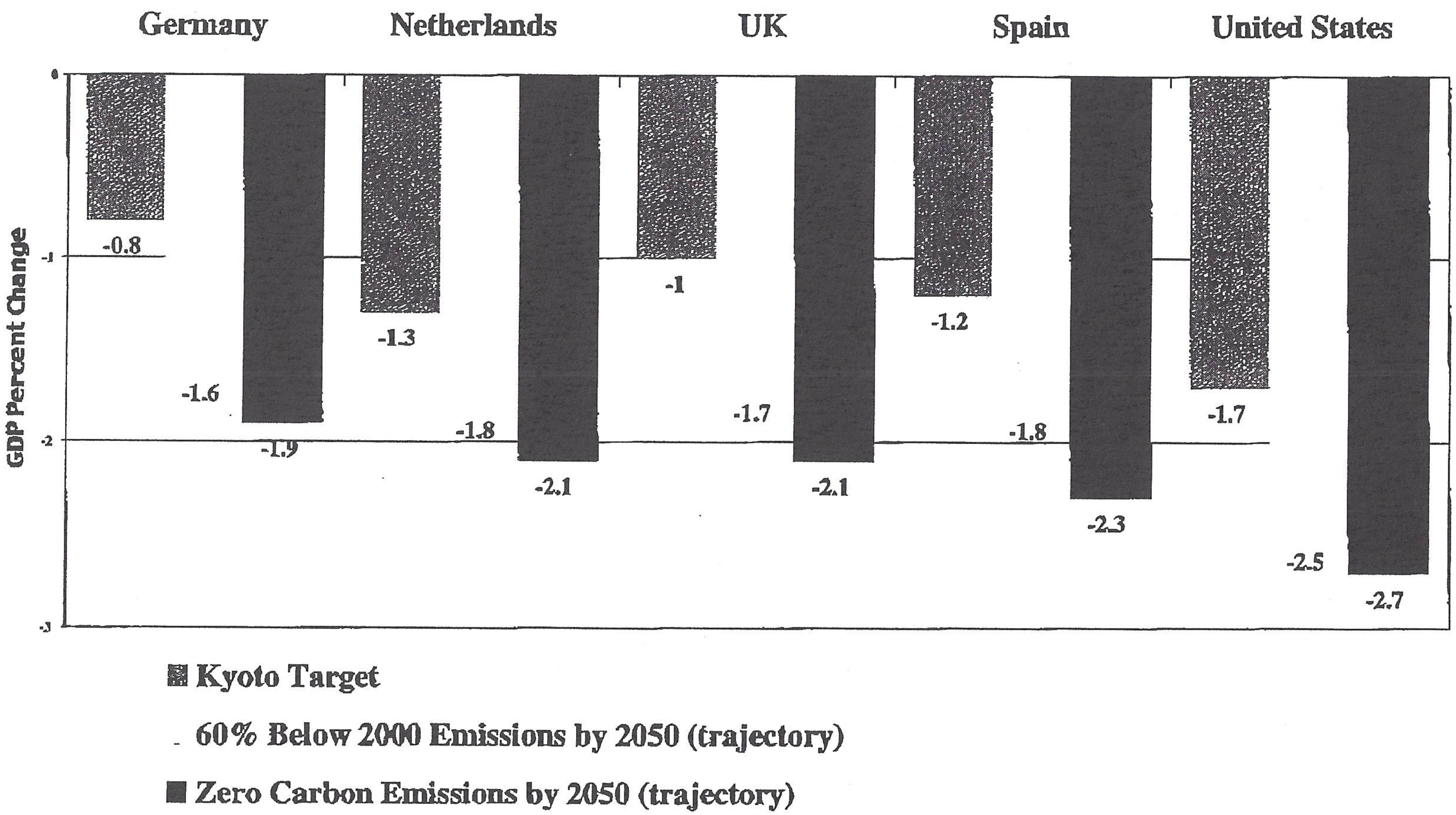
Carbon Emissions Scenario for Stabilization at 550 ppm CO_2 Cap: Developed (Annex I) Countries' Emissions Squeezed to Zero by 2050



Carbon Emissions in France: Baseline Projection and Targets



Impact of Alternative Carbon Emission Targets on GDP Levels Under the Kyoto Protocol and Under More Stringent Targets in 2020



Food for Thought

- What are CO_2 emission allowances by 2050 under "Kyoto Plus" cap?
- What is impact of Kyoto "Plus" cap on industrial competitiveness?
- With Kyoto "Plus" cap, what are the prospects for electrical generation—can you build more nuclear power plants?

A Long-Run Strategy for Climate Change and Energy Security Policies

- Develop more accurate climate change models
- Tax code reform to reduce investment costs and reduce energy intensity per dollar of GDP
- Expand nuclear energy
- Avoid near-term caps on CO_2 emissions
- Expand bilateral cooperation with developing countries and promote a truly global solution

Carbon/GDP Ratio in the United States: Baseline Projection and Targets